MEMORANDUM

Quadrant Engineering
Amherst MA

DATE: August 3, 1990

TO: Robert McIntosh and Calvin Swift

FROM: James Mead

SUBJECT: Second Interim Report, ONR Fine Scale Ocean Measurements SBIR

This report is a summary of work performed ~~during the period~~ 6/11/90 through ~~7/31/90~~ under the ONR SBIR contract "Fine–Scale Measurements of Microwave Backscatter from the Ocean Surface". Enclosed with this report is a block diagram of a short–pulse radar system that should meet all system requirements, along with a signal–to–noise analysis of the proposed system.

During the period covered by this report an effort was made to focus in on the most cost–effective way to implement a short pulse radar system, considering microwave and R.F. requirements along with the constraints of affordable, commercially available data–acquisition systems. Several competing implementations were considered, falling into two major categories: a conventional chirped radar employing dispersive delay expander and compressor devices and a stretch processor technique, using a dispersive expander and a correlation mixer. The first approach leads to a straight–forward radar design, allowing use of a commercially available matched expander/compressor pair, but requires a high–end data acquisition system in order to sample the compressed pulse every 10 nS. The second approach, following a design used by NASA in the mid–1970s for the AAFE altimeter [1], may use a more modest data acquisition system with considerably lower video bandwidth, but requires a significant increase in complication for the R.F. design.

After making inquiries into several possible commercial data aquisition systems, it appears that the speed and data rates necessary for the chirped radar approach may be feasible with a total cost around $500K. I have been in contact with a small company in California, Analatek, which is partly owned by Tektronix, on a high speed modular data acquisition, capable of very high speed conversion (up to 2 gigabytes/s) with a video bandwidth of approximately 300 MHz. There are some unresolved issues pertaining to

sustained data rate and flexibility in the number of range gates which I am continuing to discuss with their applications engineers, but at this point it looks promising.

Given that we can solve the data acquisition problem, it seems that the best way to implement the radar is to use the conventional chirp approach. One problem with the chirp radar is that the length of the stretched pulse results in a minimum range constraint. For commercially available SAW devices, it looks like the minimum range constraint will be 75 meters. To look at shorter ranges, I propose that we have an option to transmit a non–chirped pulse, and switch to the chirped pulse for ranges beyond the minimum range constraint of the expanded pulse.

The proposed design is shown in Figure 1. An operating frequency of 10.2 GHz (X–band) was selected to provide a good compromise between antenna size, resolution, cost and research value. The antenna is comprised of 128 elements, with an overall length of 5.33 meters. This will result in an effective beamwidth of .32 degrees, or an azimuthal resolution of .56 meters at 100 meters range. A SP128T (single pole, 128 throw) switching network is made by connecting SP2T and SP8T switches in a matrix. Each element of the antenna is sequentially switched to the radar, thus only one element is used for any given measurement. The response of the individual elements are combined in software along with the appropriate phase correction to form an image of the ocean surface.

Table 1 provides the parameters of the radar. From these data, SNR may be computed as a function of incidence angle. Modeling ocean σ° using [2] SNR* was computed as shown in Figure 2, showing the chirped response for ranges beyond 90 meters. A tower height of 28 meters was assumed in these calculations. An additional 20 dB of improvement due to coherent addition of all antenna elements is expected when forming the image in software.

The next stage of our work will involve a detailed evaluation of possible experiment configurations for the radar, both tower based and blimp based measurements. For each particular site we will summarize pertinent experiment constraints, such as range of incidence angles, swath width, resolution, as well as perform a first order analysis of the effects of platform motion, especially for the airborne platform. In addition, we will finalize the hardware design, which will include a hardware budget based on price quotes for all major components.

* The model used for σ° versus incidence angle was based on C–band data. According to [3], σ° is roughly independent of frequency in the range of angles between 20°–80°, and increases with frequency near grazing and near nadir.

References

[1] Hughes Aircraft Company, Ground Systems Group, "Final Report of the Advanced Application Flight Experiment Breadboard Pulse Compression Radar Altimeter Program," NASA Report No. CR-141411, Contract No.: NAS6-2558, August 1976.

[2] Attema, E. P. W., A. E. Long and A. C. Gray, "Results of the ESA Airborne C-Band Scatterometer Campaigns, ESTEC, Noordwijk, Holland, 1985.

[3] Long, M. W., *Radar Reflectivity of Land and Sea*, Artech House, Dedham, MA, 1983, pp. 267-275.

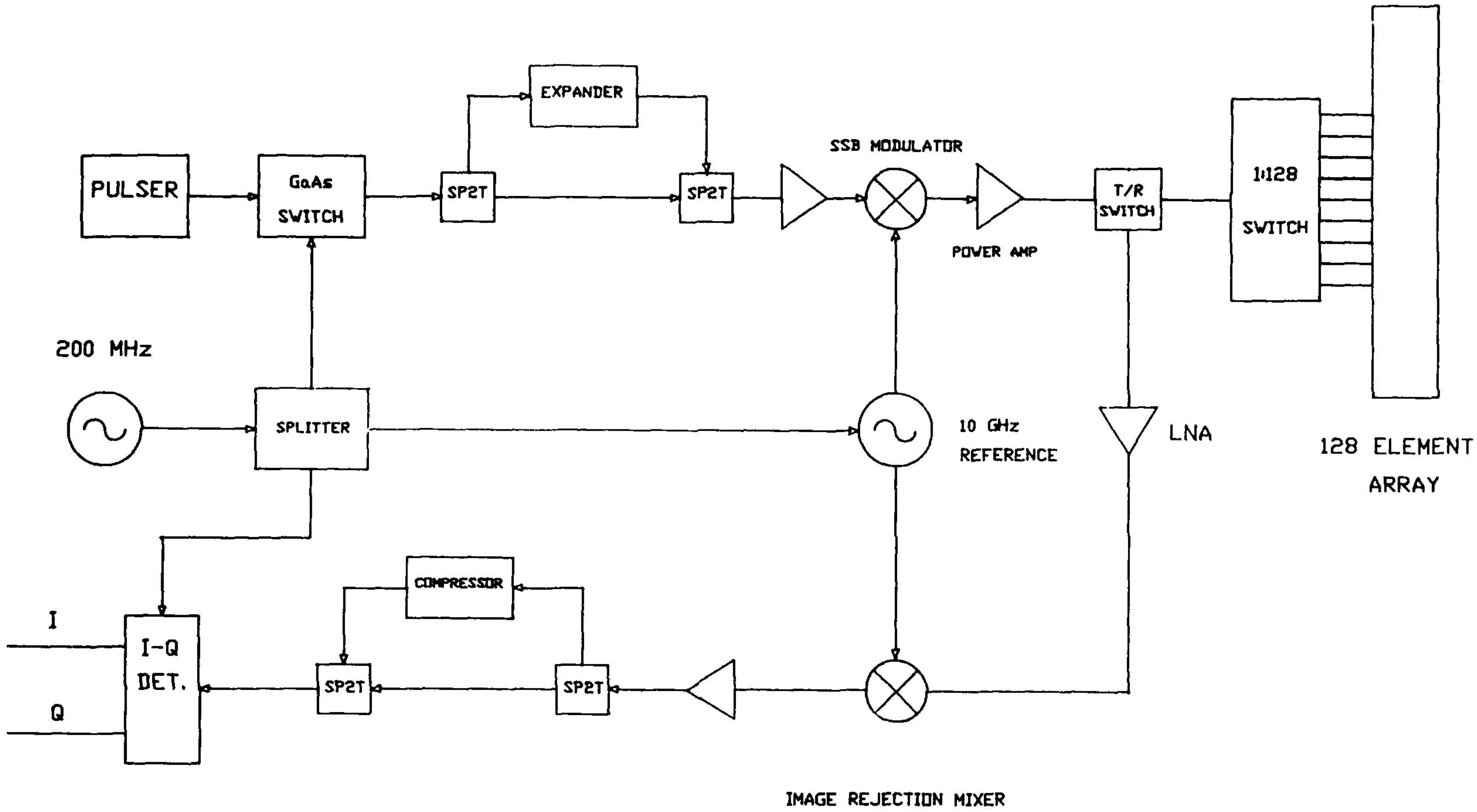

Figure 1. Block diagram of proposed focused array radar system.

Table 1. System Parameters for X–Band Focused Array Radar

Frequency:	10.2 GHz
Individual Element Gain:	18.5 dB
Individual Element Beamwidth:	20.2°
Number of Elements:	128
Element Spacing	4.1 cm
Array Width:	5.2 m
Array Beamwidth:	0.32°
Pulse Width	5–12 nS (12 nS using pulse compression; variable without)
Pulse Compression Ratio:	42
Noise Bandwidth:	83–200 MHz
System Losses (2–Way):	19 dB
LNA Noise Figure:	2.8 dB

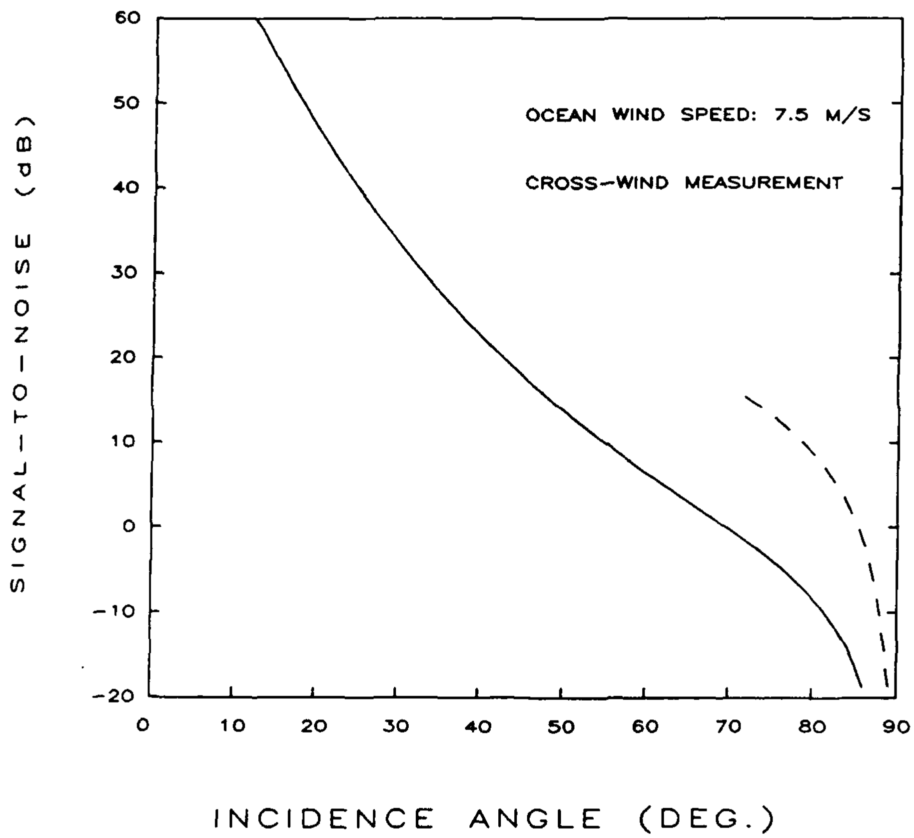

Figure 2. SNR versus incidence angle for focused array radar at a height of 28 meters (——) non-chirped pulse; (- - - -) chirped pulse.